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LABORATORY USE OF THE ACOUSTIC VALVE LEAK DETECTOR AND THE STEA--ETC(U)
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LEVEL II

From: Commander, David W. Taylor Naval Ship R&D Center
To: Commander, Naval Ship Engineering Center (SEC 6107)

Subj: Steam Trap Failure Detection by the Acoustic Valve Leak Detector and Steam Valve Leak Detector; Report DTNSRDC TM-27-78-72, Forwarding of

Encl: (1) Report DTNSRDC TM-27-78-72

1. Enclosure (1) documents the successful use of an Acoustic Valve Leak Detector and a Steam Valve Leak Detector in detecting the passage of live steam, as opposed to condensate only, through a steam trap orifice, under controlled laboratory conditions.

2. This work was supported by the Naval Ship Engineering Center (SEC 6107) under Project Order PO-80404.

W J Blumberg
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By direction

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(6) LABORATORY USE OF THE ACOUSTIC VALVE LEAK DETECTOR AND THE STEAM VALVE LEAK DETECTOR ON STEAM TRAPS.

By

(10) Joseph G. Dimmick

(11) 24 Oct 78

(12) 19p.

Bell & Howell Camera

ABSTRACT

An investigation was made of the feasibility of using the Acoustic or the Steam Valve Leak Detectors to detect steam traps malfunctioning by allowing live steam to escape. Results are presented supporting the conclusion that the use of either instrument is feasible. Recommendations were made for further investigation and specific development.

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Ref: (a) DTNSRDC Rept PAS-77-33, Oct 1977

(b) Dimmick, Joseph G. and J. W. Dickey, National Plant Engineering Conference, Chicago, Ill Apr 1978

Figs: (1) Curve; AVLD Signatures and SVLD Data, Run 1

(2) Curve; AVLD Signatures and SVLD Data, Run 2

(3) Curve; AVLD Signatures and SVLD Data, Run 3

(4) Curve; AVLD Signatures and SVLD Data, Run 4

(5) Curve; AVLD Signatures and SVLD Data, Run 5

(6) Curve; AVLD Signatures and SVLD Data, Run 6

(7) Curve; AVLD Signatures and SVLD Data, Run 7

(8) Curve; AVLD Signatures and SVLD Data, Run 8

(9) Curve; AVLD Signatures and SVLD Data, Run 9

1. Introduction

a. On 10 and 11 May 1978, Mr. J. G. Dimmick, David W. Taylor Naval Ship R&D Center, visited Armstrong Machine Works, Three Rivers, MI, to determine the feasibility of using the Acoustic Valve Leak Detector (AVLD) or the Steam Valve Leak Detector (SVLD) to detect steam trap malfunctions. Steam traps are used in virtually all Navy steam systems, afloat and ashore. When malfunctioning, they can waste considerable amounts of energy by allowing live steam to escape. The malfunction to be detected is the passage of live steam through the trap orifice. Testing by visual, thermal, or acoustical (other than the AVLD or SVLD) techniques, singly or in combination, is not always reliable. This is because, although it is often possible to determine if the automatic valve in the trap is open, there are no reliable means to detect the passage of live steam through the orifice. The problem is compounded by the process of superheated water "flashing" to steam at the discharge of a properly functioning trap. Flash steam is formed as water, under pressure and at or near saturation temperature, passes through the trap orifice to a lower pressure.

b. The R&D laboratory at Armstrong Machine Works has a header system capable of mounting eight steam traps in parallel. The test stand is equipped with isolation and blow-down valves for operating the traps singly or in parallel. Saturated steam is supplied at pressures up to 450 psig.* Condensate loading at the input header may be applied at flows up to 200,000 lb/hr. Built-in instrumentation includes pressure gages, thermocouples, and a discharge flowmeter. Traps of several types were installed in the test stand. Some were functioning normally, but most had failed in service and one had been disabled intentionally.

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*A list of abbreviations is on page 9.

c. The AVLD, reference (a), is a portable, nonintrusive instrument which senses the ultrasonic acoustic emissions characteristic of internal valve leakage through transducers which are attached to the valve and connected to the AVLD. The ultrasonic acoustic emissions are monitored by reading the front panel meter, by listening on earphones, or by recording the output on an X-Y plotter. The SVLD, reference (b), is a simplified derivative of the AVLD. It provides a measure of the average value of the total acoustic signal in the frequency range of 20 to 80 kilohertz. The signal level is read from an analog meter scaled in decibels on the front panel. Headphones may also be used to listen to the signal.

d. Although acoustic measurements were taken at normal and failed traps of both the inverted bucket and controlled disc types, work was concentrated on the intentionally disabled trap, an Armstrong Model 1010 inverted bucket trap from which the bucket and valve had been removed, leaving only the 5/64-inch orifice. This allowed concentration on the most difficult problem of steam trap failure detection and diagnosis, detecting the passage of live steam through the orifice.

2. <u>Results</u>. Initial results indicated that the flow noise through the orifice is easily detectable by the SVLD and the AVLD and that there is significant signal at frequencies up to at least 200 kHz (the upper limit of the AVLD). Because the absolute value of the acoustic signature will be a function of several variables, such as pressure, orifice size and back pressure, not generally apparent at a trap in normal service, it was hypothesized that the differential between signatures taken at the trap inlet and outlet might provide criteria usable in the field. With the transducer probe held against the flats of the input and output pipe unions, successive measurements were taken to test this hypothesis. The flow conditions were changed between measurements, and the transducer probes

were removed while the flow conditions were being changed. Flow conditions were then verified by blowing to atmosphere. The following results illustrated by Table 1 and Figures 1-9 were obtained:

a. Acoustic measurements with the SVLD were 3-5 dB higher at the input union than at the output union with live steam only (no condensate) blowing through the trap at 100 psi.

b. Acoustic measurements with both the AVLD and SVLD showed approximately equal signatures at the input and output unions when a mixture of live steam and condensate was passing through the trap.

c. Over nine successive measurements with the SVLD, the signed signature differential (output signature minus input signature, expressed in decibels) when only condensate was passing through the trap exceeded the signed signature differential where a mixture of live steam and condensate was passing through the trap by an average of 2.4 decibels. Plots of acoustic amplitude versus frequency made concurrently with the AVLD qualitatively confirmed this result.

d. The signed signature differential with condensate and flash steam exceeded the signed signature differential with the mixture of live steam and condensate by at least 1 dB in all cases, by 2 dB in two cases, by 3 dB in four cases, and by 4 dB in one case.

e. In all but one case with live steam or a combination of live steam and condensate passing through the orifice, the signed signature differential was zero or negative. In all cases with condensate only (no live steam) passing through the orifice, the signed signature differential was positive.

f. It is clear from brief analysis of the AVLD plots that in the frequency range of 40 to 140 kHz, the signed signature differential with condensate and flash steam exceeds the signed signature differential with a mixture of live steam and condensate, and that the difference is most apparent in the 60 to 120 kHz range.

TABLE 1 - SIGNED SVLD SIGNATURE DIFFERENTIAL

Run No.	Output Minus Input Signature (dB) A Condensate and Flash Steam	B Live Steam and Condensate	Discriminator (A Minus B) dB
1	4	0	4
2	3	1	2
3	2	-1	3
4	2	-1	3
5	2	0	2
6	1	0	1
7	3	0	3
8	1	0	1
9	3	0	3

Note: Each run comprised the two flow conditions during which successive measurements were made with the AVLD and the SVLD.

3. Conclusions. From the results reported herein, it is reasonable to conclude that:

a. Open or partially open valves in steam traps under pressure are easily detectable with either the AVLD or SVLD.

b. A signed acoustic signature differential of less than approximately 2 dB between the trap outlet and inlet (measured with the SVLD in the frequency range of 20 to 80 kHz) provides a possible criterion for detecting the passage of live steam through the open trap discharge orifice.

c. For the conditions under which data were collected, an SVLD frequency range of 60 to 120 kHz would provide a better discrimination capability.

4. Discussion

a. It appears from the results that, although either the AVLD or the SVLD is adequate to detect live steam passing through a steam trap orifice, neither instrument is optimal for the purpose. To detect the flow of steam, data must be taken while the valve is open, but the duration of valve opening is frequently shorter than the AVLD sweep time (about

10 seconds). The SVLD can make a measurement quickly, but its frequency range is 20-80 kHz, not 60-120 kHz, which the AVLD plots indicate would be better. Either instrument could be modified easily to provide an instantaneous measurement of the average value of the total acoustic signal in the 60-120 kHz spectrum by addition of capacitors and a selector switch. The AVLD Model C has been provided with a selector switch to be used for such a modification.

b. Signals observed were fairly close to the upper limits of the dynamic ranges of the instruments. Higher pressures or flows might require more input attenuation of the amplifiers.

c. Positive confirmation of the [illegible] of the criteria implied by the preliminary results could [illegible]ained by surveying steam traps in service, removing them, testing them in a laboratory, and comparing the field results with the laboratory results.

d. Although all steam trap operations involve continuous or intermittent flow through orifices, there are many sizes, types, and manufacturers. There are also wide ranges of pressure, capacity, and condensate loading. The entire range should be surveyed to confirm general applicability of the results presented here.

e. Many traps, including the one from which measurements were made, are designed to open intermittently. It appears that either leaking trap orifice valves or the passage of live steam through an orifice with no valve can be detected with the AVLD or SVLD, but the ability to detect the discharge of live steam through a valved orifice during intermittent operation remains to be confirmed in the laboratory and in the field.

f. Because the condensate flow rate with condensate only exceeded the condensate flow rate with condensate and live steam, there remains the possibility that the observed differences in signatures were due to differences in flow rate of condensate, rather than the presence or absence of live steam.

Resolving this uncertainty will require experiments in which the condensate flow rate is held constant, regardless of whether live steam is being supplied to the trap.

5. Recommendations. In view of the favorable preliminary results achieved, it is recommended that further research be conducted to confirm the validity and general applicability of the criteria implied by the preliminary results. The work should include experiments involving various types and sizes of steam traps, both new and used. It is especially important to conduct experiments with constant condensate flow rates to which controlled flows of live steam may be added. If the observed signature differentials persist at constant condensate flow rates, the ability to detect the discharge of live steam through a valved orifice should be confirmed in the laboratory and in the field.

a. If live steam can be detected at constant condensate flow rates, an instrument should be developed to detect steam trap malfunctions. It is anticipated that a simple adaptation of the existing SVLD will meet the requirements. Instrument development should include:

1. Determination of the instrument design parameters such as dynamic range and bandwidth.

2. Field evaluation of prototype instruments.

3. Specification development.

b. Instrument development should be followed by establishment of systematic preventive maintenance monitoring programs for steam traps.

List of Abbreviations

AVLD - Acoustic Valve Leak Detector
dB - Decibels
kHz - Kilohertz
lb/hr - Pound per hour
No. - Number
psi - Pounds per square inch
psig - Pounds per square inch gage
SVLD Steam Valve Leak Detector

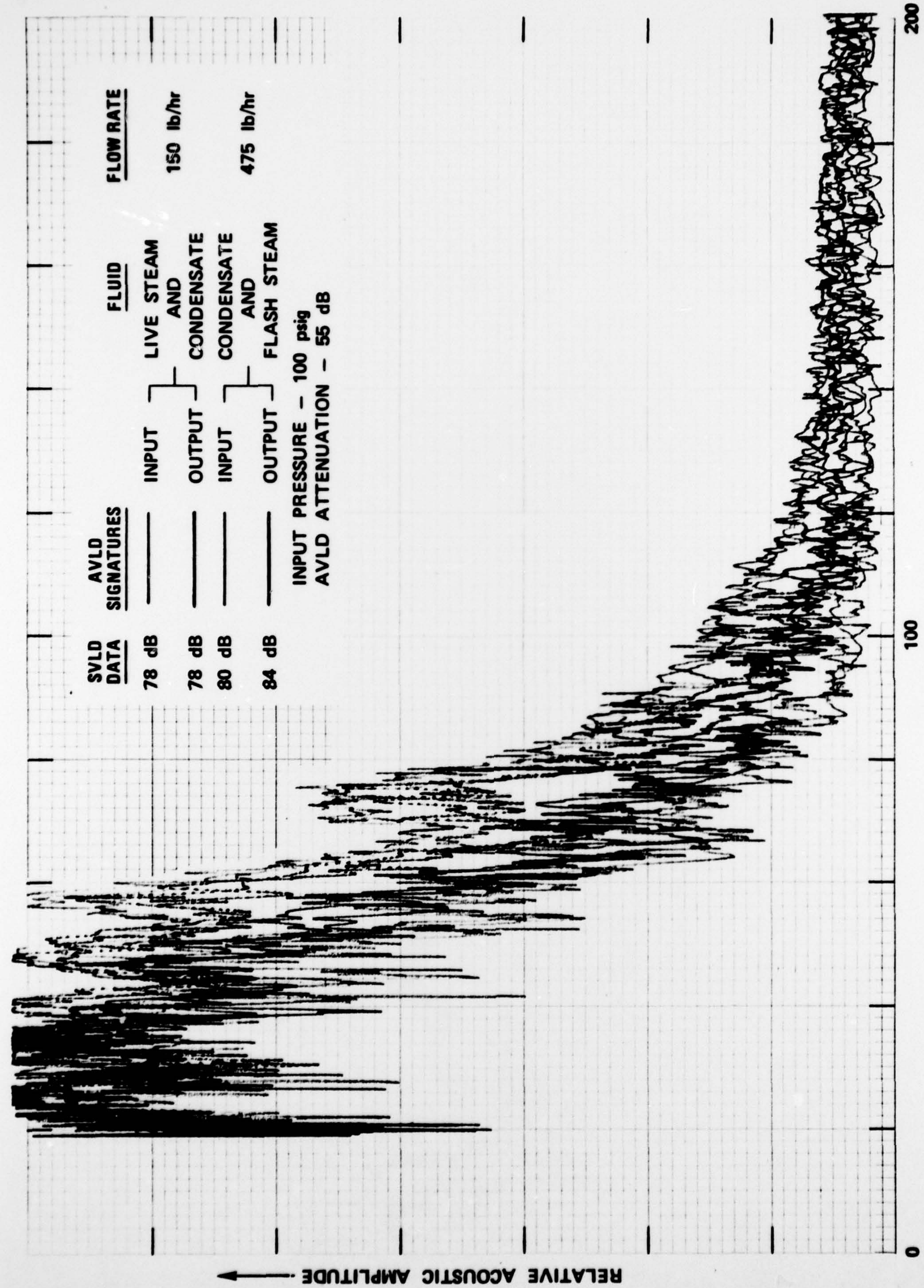

Figure 1 - AVLD Signatures and SVLD Data, Run 1

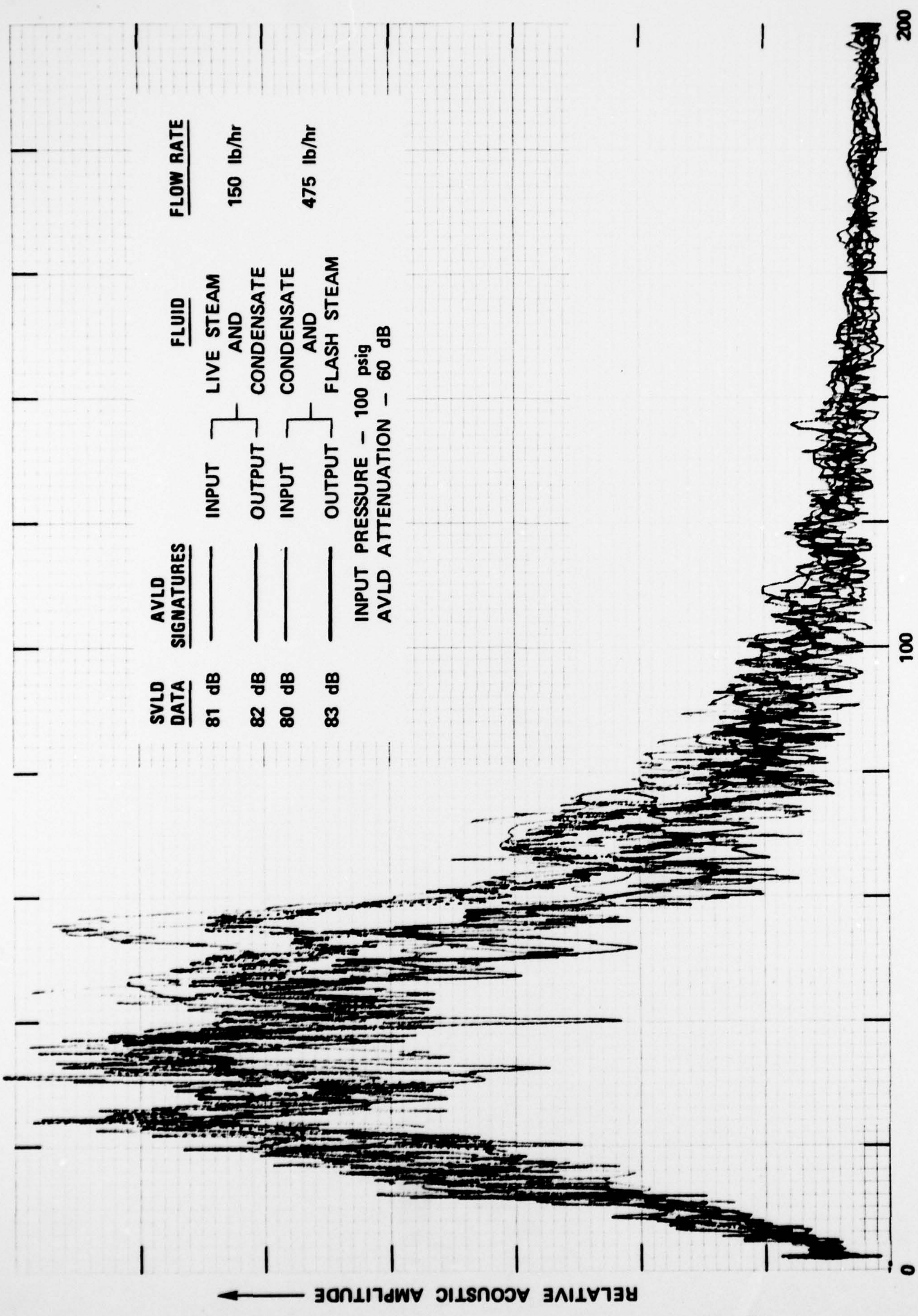

Figure 2 - AVLD Signatures and SVLD Data, Run 2

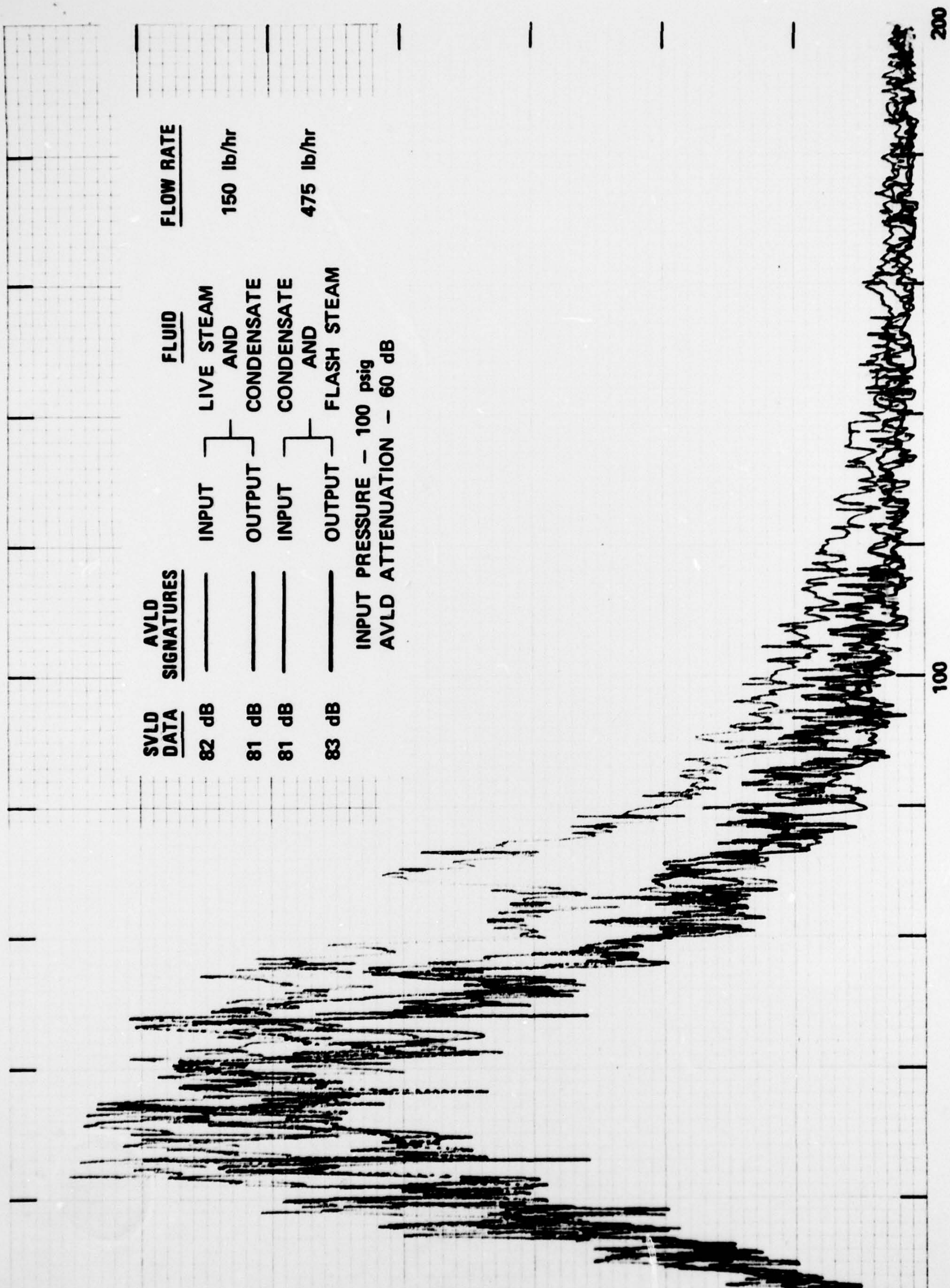

Figure 3 - AVLD Signatures and SVLD Data, Run 3

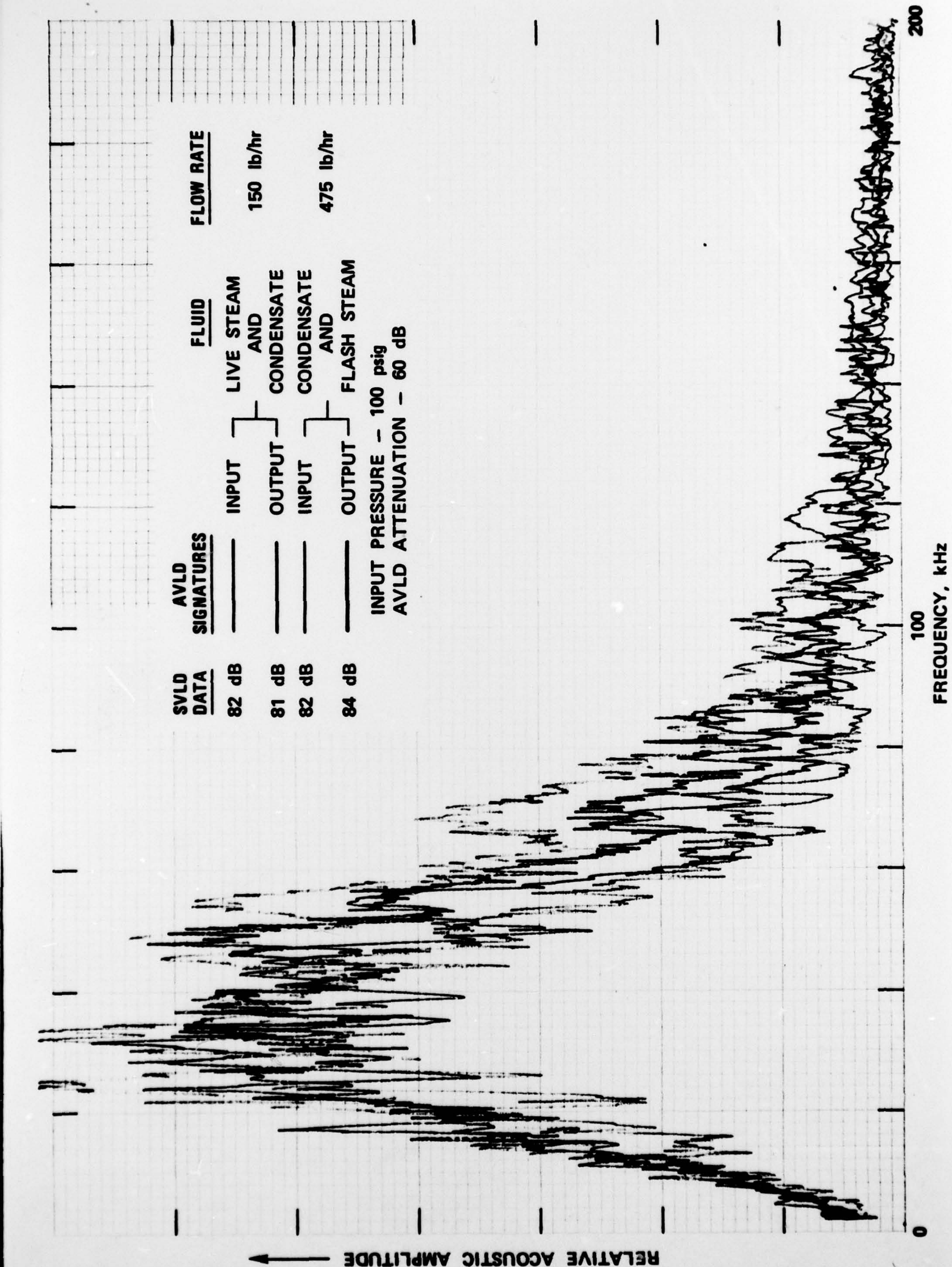

Figure 4 - AVLD Signatures and SVLD Data, Run 4

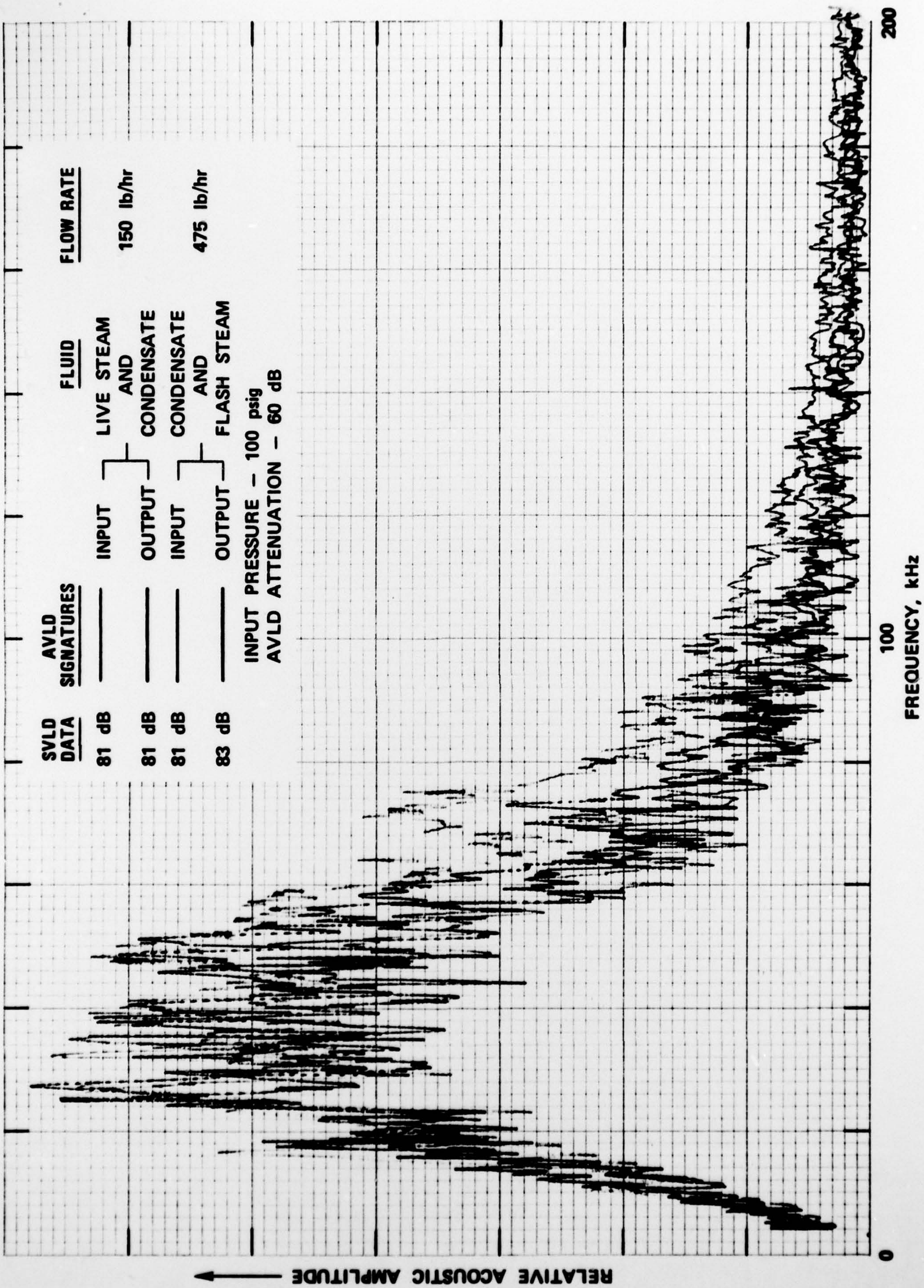

Figure 5 - AVLD Signatures and SVLD Data, Run 5

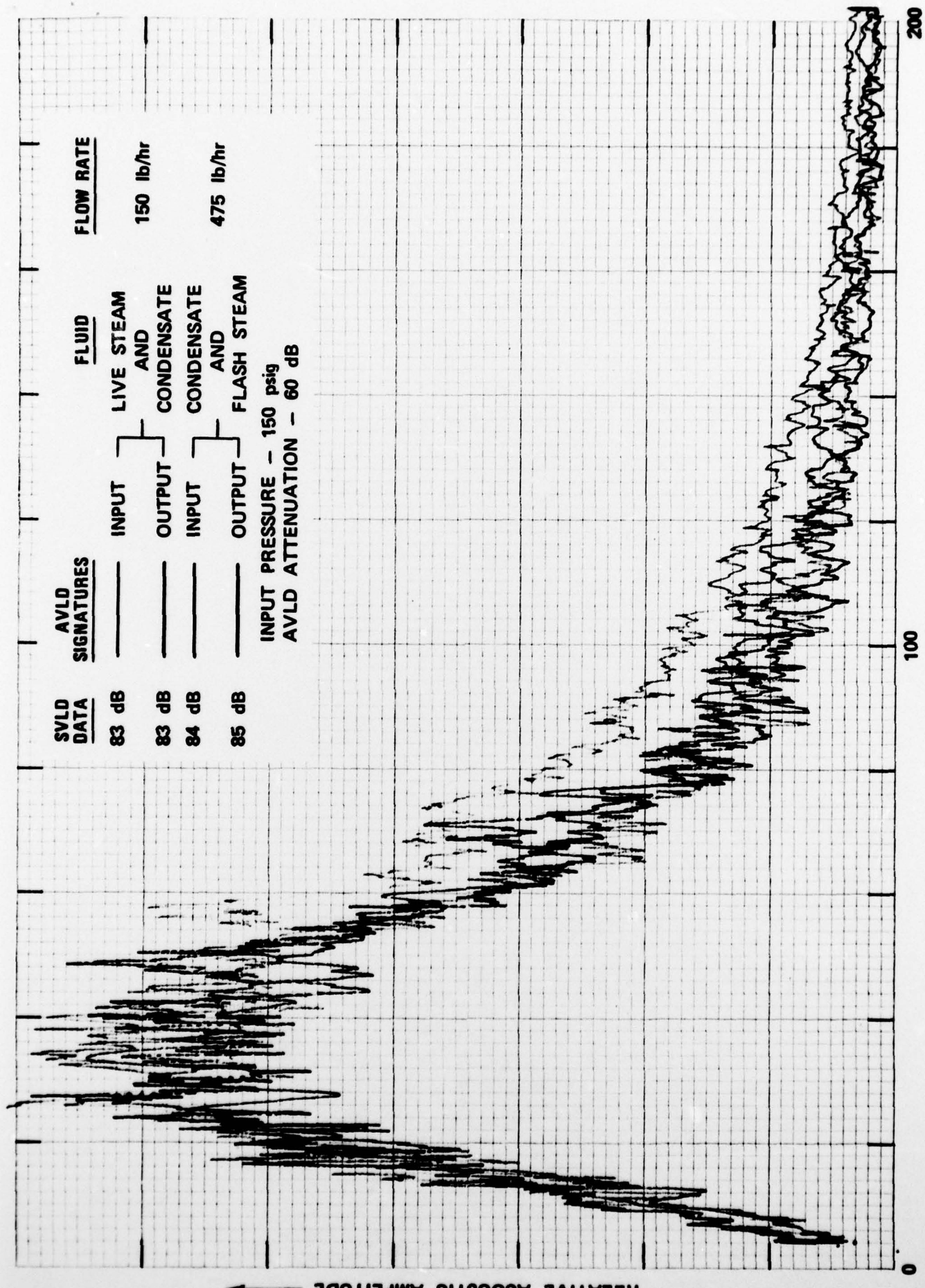

Figure 6 - AVLD Signatures and SVLD Data, Run 6

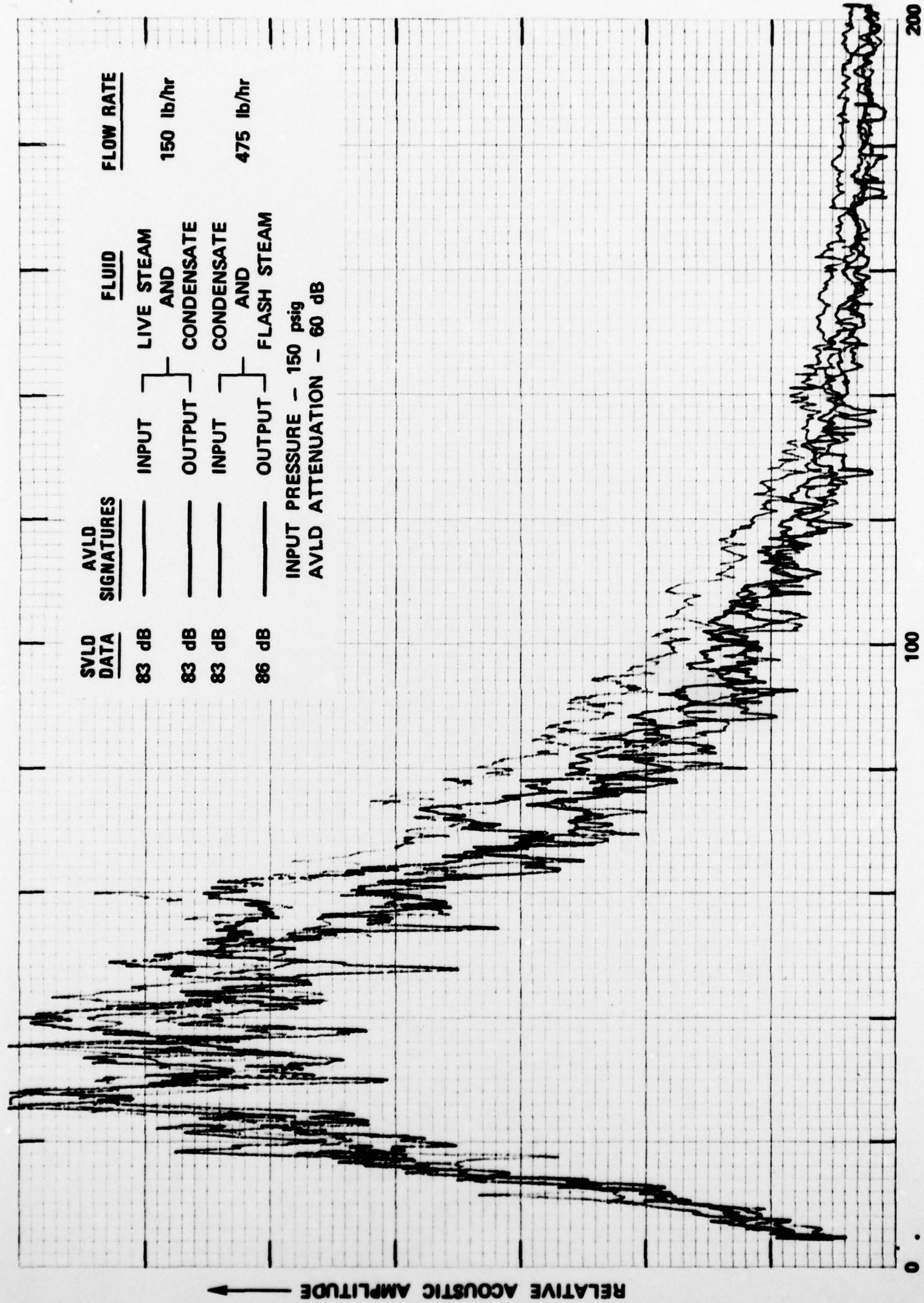

Figure 7 - AVLD Signatures and SVLD Data, Run 7

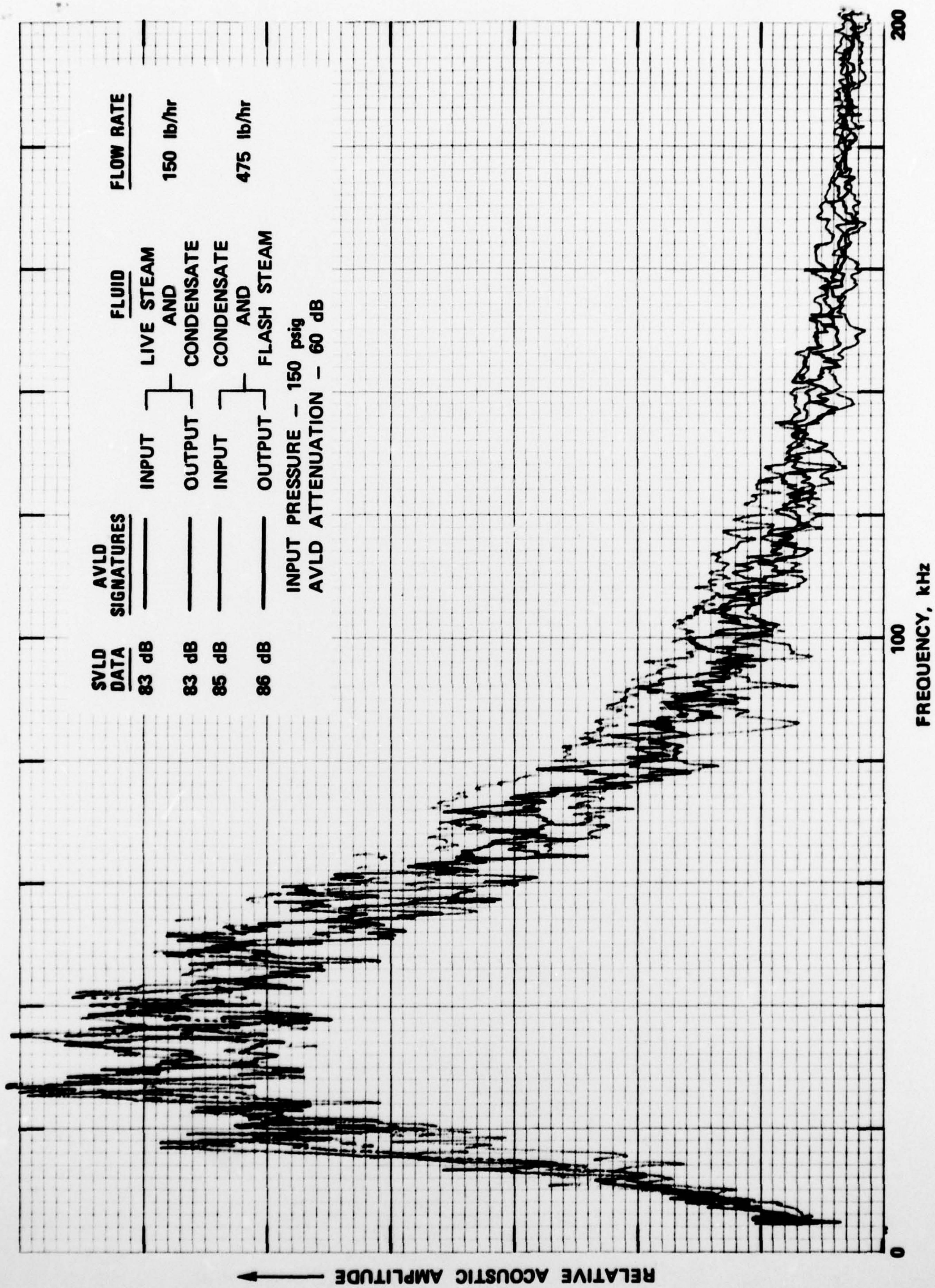

Figure 8 - AVLD Signatures and SVLD Data, Run 8

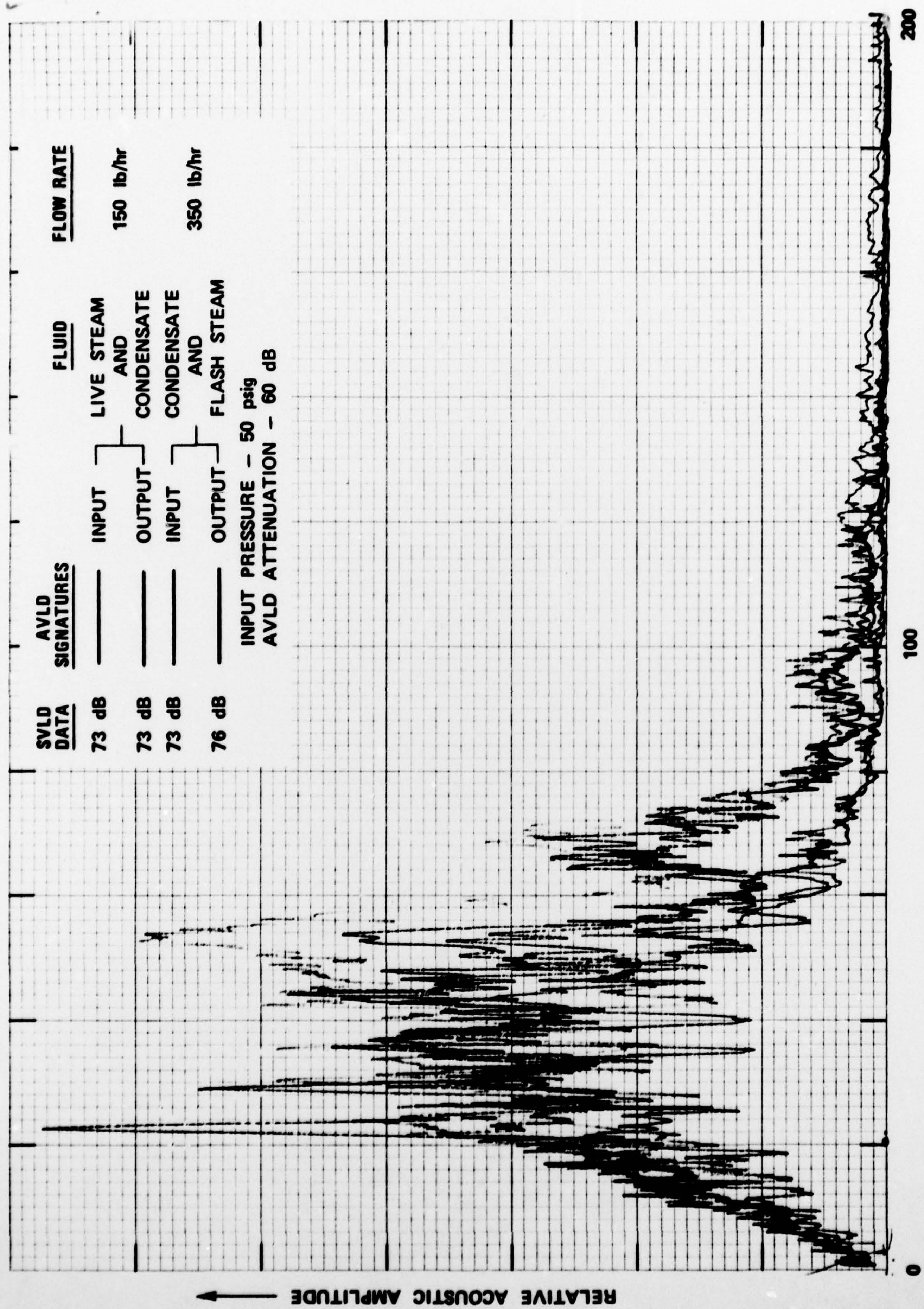

Figure 9 - AVLD Signatures and SVLD Data, Run 9